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A Linguatulid From The Alligator.



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A LINGUATULID FROM THE ALLIGATOR

BY

HOWARD RICE HILL

A. B. Carroll College, 1913

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF SCIENCE

IN ZOOLOGY

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1916

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UNIVERSITY OF ILLINOIS
THE GRADUATE SCHOOL

June 3, 1916.

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPER-
VISION BY HOWARD RICE HILL

ENTITLED A LINGUATULID FROM THE ALLIGATOR

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE

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*Required for doctor's degree but not for master's.

343173

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I. INTRODUCTION

There is probably no group of internal parasites that has been so neglected by zoological investigators as the Linguatulidae. A number of different species of this aberrant family of the Arachnida have been reported from American animals but as yet very little detailed study has been made in this country either with regard to the life history or the morphology of the group. This situation has been due, no doubt, to a lack of available material, for these parasites are not frequently encountered in animal dissections. When present, they usually occur in limited numbers, seldom more than five or six individuals being found in a single host and more often a less number. On the other hand, in tropical countries and in Europe, the Linguatulidae are far more numerous and are represented by twenty or more different species. There, certain species are known to infect even man. Consequently they have received more attention from the foreign zoologist and medical practitioner, the former has studied them from a morphological point of view while the latter has endeavored to show their pathological importance.

The injurious effects of the parasite have been frequently observed in some of the common domestic animals. On the other hand, it has long been a matter of doubt as to whether or not they seriously impair the health of the human host. But it has been shown recently by Macfie, Johnston, Chalmers and others that the larval forms undoubtedly cause a diseased condition which sometimes results in the death of the host. Macfie and Johnston give the record of five cases of larval infection in

There is probably no group of internal parasites that has been so neglected by zoological investigators as the kinestomes. A number of different species of this suborder, family of the kinestomidae have been reported from various animals but as yet very little detailed study has been made in this country with regard to the life history or the morphology of the group. This situation has been due, no doubt, to a lack of available material. For these reasons the kinestomes are not frequently encountered in zoological collections.

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native Africans who were patients in the native hospitals. In each case, the patient died after a brief illness without having shown any symptoms of a specific disease. The post-mortem examinations disclosed the presence of larvae in the liver and other organs, and an accompanying diseased condition in the region of the organs affected. The conclusion was reached that the parasites were, in each case, partially if not wholly responsible for the death of the patient. Chalmers records the case of a negro from Sierra Leone where the presence of larvae set up inflammation in the lungs and the peritoneum. In this case the parasitic infection was the immediate cause of death.

Porocephaliasis, as the disease is known, is no longer regarded as a harmless infection, and its pathological importance is now fully recognized. Therefore a thorough knowledge of the structure and development of the Linguatulidae is of value from the medical standpoint alone. Much work is yet to be done with the morphology of the group. Many species have been very incompletely described. In some instances the description of the internal anatomy has been omitted altogether. Also, the problem of development has been only touched upon by a few workers. Leuckart, Stiles, and one or two others have done some admirable work with the more common species, but practically nothing is known of the life history of the rarer forms.

In the fall of 1915, the author began the study of a linguatulid parasitic in the American alligator, *Alligator mississippiensis*. The work was undertaken at the suggestion of Professor Henry B. Ward and carried on under his direction. To him the author is greatly indebted for the material which was

used as the basis of the investigation and for advice and criticism during the progress of the study. The object of the investigation has been to determine if possible the species of the parasite and to describe its complete morphology.

II. HISTORICAL

The pentastomes or linguatulids form a group of very degenerate Arachnida and are now regarded as being closely related to the acarids. For a long time their phylogenetic position was a matter of much speculation. Wrisberg in 1765, first observed these parasites and thought they belonged to the Hirudinei. Some time later, Brasador 1774 found them infesting dogs in France and believed them true worms. In 1787, Chabert observed them in the horse and gave them the name "Tenia lanceole" and "Ver rhinaire" thus placing them in the Cestoda. The first genus, Linguatula, was established by Frohlich 1789, who described the species from the hare and named it Linguatula serrata and this proved to be the same form previously discovered by Chabert and the others. The genus Porocephalus was created by Humboldt 1811 who had obtained a different species from the American snake, Crotalis sp. He first regarded the parasite as an acanthocephalid, later as a distome and finally put it in a separate genus Porocephalus. Both genera were included by Rudolphi (1819) in a single new genus Pentastomum which has been used extensively. The genera Linguatula and Porocephalus, according to rules of zoological nomenclature can not be disregarded and at the present time are recognized as correct rather than Rudolphi's genus.

There has been a considerable difference of opinion as to the affinities possessed by the Linguatulidae. Rudolphi thought they belonged to the Trematoda while Nordmann 1832 believed them near the Nematoda. Their exact position was

not thoroughly established however, until van Beneden in 1848 showed their true crustacean character and placed them near the Lernaeidae. It was left to Schubart (1853) and Leuckart (1860) to point out their close relationship with the Acarina and following them, Railliet has confirmed their conclusions. On the other hand, Ihle (1889) differs from the views taken by Leuckart and the others and places them in a subphylum of the Tracheata. More recently, Sambon (1910) agrees with Leuckart and gives some additional reasons for placing them along with the Acarina. He believes their vermiform appearance and structural modifications have been brought about by an endoparasitic mode of life. The blood sucking habit and the fact that they foster the sporogonic cycle of haemogregarines of the reptilian hosts, at once suggests relationship with the ectoparasitic Ixodidae.

III. EXTERNAL ANATOMY OF THE FREE LARVA

The material which was placed at my disposal consisted of a collection of twenty nine linguatulids from the lungs of *Alligator mississippiensis*. The specimens were obtained July 24, 1915, near Mandeville, La. and were in good state of preservation, the preserving agent being formol. Twenty two of the specimens were in the free larval stage of the parasite while seven were enclosed within cysts.

The free larvae were more or less bent and twisted, a fact which might indicate that they had escaped from their cysts only a short time before they were taken from their hosts. Eight of the twenty two were injured to some extent, one or both ends having been broken away. The remainder, however, were entire and offered a good opportunity for the study of the external anatomy. The specimens were first studied in a liquid medium (Alcohol 75%) under the dissecting microscope. All the specimens in the material unfortunately proved to be males. Otherwise additional comparisons might be made between the two sexes with regard to structure and size. The males, however, show the characteristics of the species at hand.

Description. The larva is of a dirty white color, slightly tinged with yellow. The form of the body is cylindrical, elongate and worm like, tapering toward either end (Fig. 1). The ends are rounded and the posterior end is slightly wider than the anterior tip. The specimens vary considerably in size as can be seen from the following table.

Table I.

Specimen	Annuli	Length	Width at 10th annulus	Width at 30th ann.	Width at 50th ann.
A I	64	4.08 mm.	0.522 mm.	0.581 mm.	0.290 mm.
A II	62	5.4	0.437	0.48	0.304
A IV	60	4.35	0.342	0.43	0.247
A VII	64	5.2	0.513	0.53	0.418
A VIII	66	4.2	0.561	0.57	0.323
A IX	60	7.	0.561	0.589	0.399
F I	62	4.1	0.532	0.54	0.38
F II	65	4.18	0.38	0.418	0. 247

The average length is 4.8 mm. and the average width at the center of the body is 0.525 mm. The body is divided into quite distinct regions. The greater part is taken up by the posterior abdominal region which is covered with a series of rings or annulations nearly uniform in width. In different individuals the number of the annuli varies from 60-66, but the specimens of greatest length do not necessarily have the largest number of rings. The short anterior head region or cephalothorax is completely devoid of annuli but a number of folds or rugae are present which give the lateral edges a rough outline (Fig. 2r).

Cephalothorax. This region is about equal in length to the breadth of the body at the anterior margin of the abdomen. From this margin, the head rapidly narrows in width toward the anterior tip which is the narrowest part of the body. Measurements of the cephalothorax.

Table II.

Specimen	Length	Anterior width	Posterior width
A II	0.304 mm.	0.209 mm.	0.266 mm.
A III	0.323	0.2	0.342
A IV	0.204	0.19	0.266
A VII	0.266	0.19	0.361
A VIII	0.247	0.171	0.361

A lateral view shows the cephalothorax to be flattened dorsally and flexed ventrally at an angle of 45 degrees. The bending begins in the anterior part of the abdomen, in the region of the fourth anterior annulus.

In order to bring out the more minute structures of the head and abdomen, a number of toto mounts were made of both stained and unstained specimens. Borax carmine, altho penetrating more slowly than some of the other stains, was found to give the best results.

Upon closer examination of the cephalothorax with higher magnification, a number of additional structures are to be observed. On the midventral line, about half way between the anterior tip and the first annulus, is situated the mouth opening, bordered with a chitinous band. On either side of the mouth there are two hooks, lying about midway between the lateral edge of the body and the midventral line. The hooks are set obliquely away from the mouth at an angle of 25 degrees. They are two pronged and consist of a straight upper projection and a lower basal portion in which the outer extremity is

strongly recurved. On the lateral edges there are several prominences; they are equidistant from the median line, arranged in pairs, three on either side. These are the papillae or organs of special sense.

Mouth. The mouth is recognized by an oval or pear shaped ring of chitin, lying in the midventral line, 0.095 mm. anterior to the first annulus and 0.076 mm. from the anterior end of the body. It is 0.1 mm. long and 0.062 mm. wide at the center and gradually narrows to a width of 0.025 mm at the anterior end. The lower apex narrows more rapidly until it measures 0.016 mm. in width at the lower margin. The chitinous border is thickest along the center of the mouth where it is 7 micra in thickness, and thinnest along the posterior margin where it is 2 micra wide. In the anterior region of the mouth, the oral papilla, a triangular shaped projection extends out from the border. From the ventral side it is hardly discernable, but viewed laterally and in cross sections it is very evident. Together with the other papillae of the cephalothorax, its function and structure will be discussed in another place. A sort of flap is attached to the lower border and extends inward on either side to a width of 0.01 mm. while along the posterior apex of the mouth its width is 0.014 mm. This flap does not reach as far as the center of the mouth and is only present along its lower border. In many of the specimens the flap could not be detected, but in others it is readily apparent. Attached to the flap and the border are the pharyngeal muscles leading

down into the pharynx. They extend entirely around the inner wall of the mouth and thicken at the anterior apex where there is a short interval measuring 0.019 mm. caused by the breaking of the chitinous border.

Hooks. The double pointed hooks which are used by the parasites for attaching themselves to the tissues of the host, lie on either side of the mouth. They are golden yellow in color and are composed of a hard chitinous substance. The anterior pair are slightly nearer the midcentral line of the body and are not quite as large as the posterior pair. Where the hooks enter the body, the cuticle is folded back and a ridge is formed around each external base, with a slight depression between the ridge and the hook. These depressions are known as the hook pits and are common to most species of Linguatulidae. In this case they are comparatively narrow and can only be detected in mounted specimens.

In order to further describe the position of the hooks, it will be necessary here to go somewhat into detail with regard to their structure. Each hook is composed of three distinct parts, (1) an upper accessory spike with a long narrow basal plate, (2) a lower sharply recurved hook with a broad base, (3) a very thin chitinous sheath which covers the basal portion of the upper projection and a part of the base of the lower hook. The total length of the accessory spike is 0.29 mm. and about one third of this length is the only portion visible outside of the body. The width of the long basal plate within the body is 0.018 mm. When the exterior is reached, the spike begins to narrow and

tapers off to a sharp point. The basal plate on the other hand is quite constant in width until the inner end is reached where it suddenly rounds off. The projecting part lies closely approximate to the top and anterior side of the lower hook. The lower hook is bent at a sharper angle than the upper thereby causing 0.041 mm. of the spike to stand out free. The shortest distance from the point to the surface of the lower hook is 0.021 mm. At the place where the internal prolongation begins there is a slight incurvature of the upper edge and a corresponding widening at the lower edge approximate to the lower hook. The anterior side of the lower hook is accordingly indented to some extent. A dark shaded portion in the center of the main spike shows up prominently. This indicates, perhaps, that the spike is hollow and that there is a median groove, though no outlet to the groove can be seen. Examination of a cross section of the hook at this point shows the hollow character of the accessory spike very plainly. With respect to the function of the accessory spike, it is probable that it serves a double purpose. In the first place it acts as a catch or anchor for the main hook. Piercing the tissue of the host at a different angle, it tends to prevent the dislodgement of the lower hook until it is finally broken off at the end of the larval period. Furthermore, it is a source of irritation in the tissue, causing blood or mucous to be secreted. This the parasite immediately uses as food by sucking it down its large mouth opening. The portion of the spike within the body

together with the overlying sheath act as a base of support for the entire hook. To them most of the hook muscles are attached, some connecting with the lower hooks, others with the body.

The lower hook is much broader than the accessory spike, but not as long. It is otherwise different in that it is more strongly curved and has a frontal supporting plate on the lower side. Its length taken thru the center is 0.06 mm. The length of the inner portion is 0.025 mm. at the center and 0.039 mm. in the region of the supporting plate. Soon after leaving the body the hook begins to narrow and then bend inwardly until 0.05 mm. of its outer length lies parallel with the supporting plate of the lower side. It terminates in a sharp point which is closely approximate to the body surface. This position of the lower hook allows the mouth to come into close contact with the tissue of the host. The frontal supporting plate at the lower edge is 0.014 mm. wide and is somewhat fan shaped. Near the end it has a triangular projection on the inner side which extends out into the adjacent muscle fibers. A muscular band fills up the center of the hook for a distance of 0.035 mm. and ends abruptly near the center of the hook just without the body. The muscles within the band and the other hook muscles will be dealt with later under the muscular system. Here, as in the upper hook, there is a darker central region in the portion of the hook within the body, suggesting the presence of a hollow chamber within.

An extremely thin chitinous sheath fits closely over the basal plate of the accessory spike and a small portion of the lower hook. It no doubt serves as a protection for the upper hook muscles, and to bind tightly together the upper and lower hooks. The width of the sheath is 0.035 mm. and the length 0.19 mm. extending inwardly a little beyond the end of the basal plate. It is quadrangular in shape and fairly uniform in width. The outer termination lies within the body and is more or less square across, while the inner termination is rounded. The outline is similar to that of a banana. There are muscle connections with the lower hook both from the outer and inner surfaces of the sheath.

For a short distance from the pointed ends the hooks are perfectly round, but as they approach the point where they start to bend there is a gradual broadening in the vertical plane. This condition is more noticeable in the lower hook. here the center of the hook is nearly twice as broad as thick.

The basal plate of the upper spike and the sheath form the main supporting base for the whole hook. They are bent at the middle, thus throwing the hook forward, and giving them the outline of an arc. The supporting plates of the posterior pair of hooks have a broader curve than those of the upper pair. This tends to set the lower hooks farther out from the median line. The distance between the frontal plates of the anterior hooks is 0.2 mm., and in the posterior pair 0.232 mm. The supporting plates of the posterior hooks lie just without the lower border of the mouth, while the position of the mouth with regard to the plates of the

anterior pair is directly ventrad. The lower margin of the mouth is on the same plane horizontally as the posterior end of the frontal plates of the posterior hooks, while the upper edge of the mouth is on the same plane with the plates of the anterior hooks. The distance between the anterior and posterior hooks is 0.1 mm. measured from the anterior surface. The supporting plates in the anterior hooks nearly meet in the median line while those of the posterior pair are 0.035 mm. distant where they come nearest together. The posterior margins of the supporting plates in the posterior hooks are 0.036 mm. anterior to the first annulus.

Papillae. There are six prominent papillae along the lateral margin of the ventral surface of the cephalothorax. They lie just without the line of the hooks, three on each side of the head. They are arranged in three pairs, the papillae in each pair being exactly opposite. The first pair or primary papillae are slightly larger than the others and jut out from the extreme anterior border of the ventral face, one at each corner. The distance from the base of each to the middle is 0.034 mm. and to the edge of the anterior hook pits 0.035 mm. The papillae are all of the same shape, a cone with a rounded tip. The base is the widest portion and there is a gradual decrease in width to the tip which rounds off abruptly. The primary papillae are 0.02 mm. in length, 0.028 mm in width at the base and 0.018 mm. in width at the tip. The first pair of secondary papillae are 0.012 mm. further from the midventral line and lie 0.015 mm.

anterior to the first pair of hooks. They are 0.027 mm. from the base of the primary papillae. The third pair lie on a even line with the posterior hooks and 0.03 mm. posterior to the second pair. They are 0.061 mm from the midcentral line and in size agree with the secondary papillae. The oral papilla which arises from the mouth opening can only be detected by viewing the cephalothorax from the side. It nearly fills the space of the mouth aperture and is longer and more stretched out at the base than the other papillae. It is triangular in shape, the apex pointing anteriorly and the posterior margin being the broad end. The distance to the tip is 0.028 mm. and the base measures 0.02 mm. wide in the horizontal plane and 0.045 mm. wide in its broadest part. At the lower border is the transverse opening which leads directly into the pharynx.

Rugae. The cuticle in the posterior part of the cephalothorax is ridged transversely, giving the lateral margins a rough outline. The rugae or folds are narrow and uneven. They begin just anterior to the first annulus and are present as far forward as the posterior hooks where the cuticle presents an even surface. In some specimens it is difficult to determine where the annuli begin because of the similar notched appearance of the lateral edge in the region of the first annuli and the posterior part of the cephalothorax.

Abdomen. The abdomen occupies the greater part of the length of the body. It is somewhat flattened along the ventral surface and rounded at the posterior end. It is considerably wider than the cephalothorax except at the

extreme end. The average length is 4 mm. and the average width is 0.5 mm. Soon after leaving the cephalothorax, it begins to widen and reaches its maximum width in the region between the sixteenth and twentyfirst annuli. From that region, it gradually decreases in size posteriorly. The posterior third is bent ventrally at an angle of about 45 degrees. Along its whole length, it is marked by a series of rings or annulations. These are fairly uniform thruout except in the center of the body where they widen perceptibly. The average length taken with respect to the long axis of the body is 0.3 mm. and the width conforms to that of the body. The terminal annulus is cone shaped and slightly longer than the preceding ones. It bears the subterminal anus on the midline of the ventral side, 0.03 mm. from the posterior tip. Each annulus is divided into two portions, the anterior larger portion which slopes gently toward the front margin and a posterior raised portion. The posterior part slopes abruptly towards the posterior edge, and bears at its anterior edge the rows of spines which point posteriorly.

Spines. A border of sharp pointed tooth like projections extends entirely around the body, just posterior to the center of each annulus. They lie along the ridge that separates the annulus into two parts, the sharp ends pointing posteriorly. The average distance between the spines is 5 micra. In some places they are huddled close together while in others they are stretched apart. Each spine is the shape of a pen point with its base extending thru the cuticle

into the epithelium beneath. The average length is 9 micra and the width thru the base is two micra. The cuticle is attached to the sides until the spine begins to slope toward the point. Between the spines, where they are not stretched apart, the cuticle sags inwardly. This indicates that the spines are able to move from side to side. However, there are no muscles connecting the base with either the epithelium or the cuticle.

Stigmata. A row of small round pores or stigmata extends completely around the body in the anterior region of each annulus. Their position is just anterior to the center of the annulus. Their arrangement is sometimes irregular for they do not always form a straight line. Altho no definite border surrounds the pores, they give the appearance of being slightly raised from the surface of the cuticle. In diameter they measure 1.5 micra and the distance between them is 21 micra. In the cephalothorax they are lacking altogether.

Genital Opening. The male genital opening lies on the midventral surface of the center of the first annulus. It is oval in shape and surrounded by a narrow raised border. Around the outer portion of the border is a low area in the cuticle. The length of the opening in an antero-posterior direction is 20 micra and the width is 12 micra while the width of the surrounding border is 3 micra.

Alimentary Tract. The long yellowish brown intestine, extending thru the entire length of the body

is the first prominent internal structure to be noted. The anterior portion is somewhat extended, while in the posterior region of the body, its width is more or less uniform. Soon after leaving the cephalothorax, it begins a lateral bending, which is more pronounced in the middle region of the body. As the posterior end is approached, there is a gradual straightening. Two large masses of cells are present on either side along most of its length.

IV. INTERNAL ANATOMY OF THE FREE LARVA.

Technique. A number of series of cross sections were made in order to study the arrangement of the internal structures, and to check up with the observations made of the toto mounts. In addition several specimens were sectioned longitudinally to show to better advantage the relationships of the muscles of the body wall and other structures. The stain used was Delafield's haematoxylin which was found satisfactory in every way and especially good for bringing out the chromatic material of the reproductive organs and the cell nuclei.

Structure of the Body Wall. A transparent non-cellular membrane or cuticle covers the entire body surface, and extends into the mouth aperture, the anal opening and the hook pits. It is composed of hard chitinous material that is resistant and impermeable to liquids. In staining specimens, it is necessary to leave them in the staining fluid a longer time than is customary with most tissues. Extra time must also be allowed for infiltration in the paraffin bath because of the poor penetration thru the cuticle. In cutting sections, unless the knife is exceedingly sharp, the cuticle is resistant to the edge and tears thru the section. In thickness, the cuticle is uniform over all parts of the body except along the hook pits, where there is a slight decrease in thickness. On the outer edge is a very narrow border that stains darker than the rest. It is 1 micron thick while the main cuticle is 11 micra in thickness. Seen in cross

section, the cuticle is quite transparent and devoid of cells except where the stigmata break thru from the epithelial lining beneath.

A single scattered row of cells is present directly beneath the cuticle. They are uniform in size and measure 0.04 mm. in diameter. In the anterior region of each annulus, just below the stigmata, numbers of these cells are often masses together with their rounded ends pointed away toward a common center. Their function is probably of a secretory nature and connected with the work of the stigmata as a short narrow canal leads from these cells to the stigmata.

There are three types of muscles in the body wall, (1) transverse, (2) longitudinal and (3) oblique. The first set of muscles below the subcuticular epithelium is a thin layer of transverse muscle fibers, which is present over the entire body except in the head region. The transverse fibers are usually one layer thick but are occasionally arranged in a double layer. A cross section thru the body wall shows the fibers to be hollow, and circular in cross section. The layer is uniform in thickness around the circumference of the body, a condition unlike that which Spencer found in *P. tertiusculum* where the transverse layer thinned out along the dorso-lateral region of the body wall.

The longitudinal layer which lies directly below the transverse layer is thicker than the former and arranged in a different manner. Two layers of fibers are continuous over the surface, except ventrally in the region of the hooks.

Along the circumference there are six regions where the fibers tend to band together and thicken the layer into more than two rows. The two lateral bands contain the greatest number of fibers and form a sort of lateral line. Spencer attributes this lateral line to the thinning out of the transverse fibers at this point, but in this case the transverse fibers are present in normal numbers. The longitudinal fiber is hollow like the transverse type but the nucleus is larger and stains a darker color than the former.

The oblique muscles are attached to the lateral body wall 0.031 mm. from the middorsal line and extend obliquely across the body cavity to a point near the midventral line of the body wall. The fibers are arranged in parallel rows on either side of the body. They are placed a little apart from each other and do not form a continuous layer. The ends are often split into fibrils which become embedded in the network of parietal cells along the edge of the body wall. Toward the posterior end, caudad of the hook glands, the oblique muscles divide the body cavity into three parts, the large central cavity and the two lateral pockets. In the hook gland region, the fibers do not stand out prominently, but are wedged in between the glands and the body wall. In some instances where the hook glands are smaller and not diffuse, the oblique fibers stand out free. In the cephalic region the oblique fibers are lacking.

The Hook Muscles.

The muscles of the hook take up the greater part of the space in the head region. They are arranged in four fan shaped masses, two connected with the hook itself, while the other two sets are attached to the basal supporting plate. The flexor of the hook is attached to the posterior side of the frontal plate and spreads out as it extends toward the lower portion of the basal supporting plate where it ends. Its function is to bend the hook so the point of the main hook moves toward the surface of the body. The extensor muscle connects with the hook at a point near the upper angle of the main hook not far distant from the end of the sheath. It extends back to the posterior portion of the sheath and basal supporting plate where a portion is attached and the remainder passes on into the body wall. The extensor is the largest of the hook muscles and its function is to throw the hooks forward. The external protractor connects the upper portion of the sheath with the body wall. It spreads out towards the anterior median line and its action causes the hook to be thrown forward and down. The ventral retractor, the smallest of the four muscles, arises at the lower end of the frontal plate near the bottom of the hook pit. This muscle extends posteriorly and its function is to aid in retracting the hook. A cross section thru the hooks shows additional muscle fibers, indefinitely arranged, attached to the sides of the hook pit. Their purpose is to pull back the walls of the hook pit as the hook is extended.

Organs of Special Sense. The papillae of the cephalo-thoracic region are recognized as organs of special sense. This is undoubtedly true with respect to the primary papillae where there is a nerve which extends to the tip and a median narrow canal leading to the surface. A lateral view shows the division of the cuticle at the end of the papilla and the tube passing up between is the upper prolongation of of the hook gland duct. In the other lateral papillae neither duct or nerve is present and the cuticle extends evenly over the surface of the papillae. The primary papillae are the "Tastpapillen" of Leuckart who considered them organs of taste. It is more probable however, that they serve as touch sense organs. Spencer is of the opinion that they are used for feeling and smelling. The inner lining of all the papillae is similar. A single row of epithelial cells is present and in the primary papillae they extend down either side of the hook gland tube. In the oral papilla, there are in addition, longitudinal muscle fibers below the cuticle.

Glandular Structures. The hook glands are the largest structures of the body cavity. They are arranged in a single pair, one gland on either side of the alimentary canal. Beginning slightly below the atrium genitale, they extend to the fifteenth annulus from the posterior end of the body. In shape they are long and cylindrical and taper somewhat posteriorly. They are connected to the alimentary canal by mesenteries, one on either side of the canal. Each mesentery consists of a main strand with branching fibers at

the ends which connect with the gland wall and the wall of the alimentary canal. A network of thin fibers crosses the larger strands. Exactly in the center of the main strand is the hook gland duct. The cells composing the hook gland are the largest cells of the body. They are triangular in shape with the corners rounded, the narrow ends pointing toward the hook gland. In each cell a large, deeply staining nucleus is present and a delicate membrane surrounds the cell. The cells vary in size in the same specimen, the average length being 0.09 mm., but some measure as much as 0.17-18 mm. they are arranged in closely packed masses and not in a definite layer. In some specimens the hook glands are much more diffuse than in others. Here, they take up nearly the whole body cavity, and crowd the oblique muscles to the body wall. In younger specimens their size is limited and they are seldom over three or four times as large as the intestine. Various theories have been put forth as to their probable function. Spencer suggested that they secrete a substance to prevent the coagulation of blood, which is a part of the food of the parasite, while Leuckart believed their secretion irritates the tissue of the host, thereby causing more mucous and other nutrient material to be given off.

Head Gland. In the center of the head region there is a mass of cells similar in character to the hook gland cells, but smaller in size. These comprise what is known as the head gland. In cross section the gland appears slightly dorsal to the basal supports of the hooks as a more or less scattered group of cells without a limiting membrane.

Parietal Cells. The parietal cells appear along the lateral edge of the body cavity in the abdomen and completely encircle the body cavity in the cephalothorax. In the abdomen they lie approximate to the body wall in the body cavity and lateral to the oblique muscle fibers. They are usually arranged in parallel double rows, but occasionally they thin out to a single layer toward the dorsal and ventral mid-lines of the body cavity. The cells are similar in character to those of the head and hook glands, but do not stain as deeply. In the head region they are most prominent along the dorsal wall of the body cavity, and in many places are almost continuous with the cells of the head gland. They are quite uniform in size and average 0.016 mm. in length. There is no duct or canal connecting them with any other structure.

Alimentary Tract. The alimentary tract is in the form of a long simple tube, varying in width and structure thruout its length. It has six divisions; (1) oral papilla, (2) mouth, (3) pharynx, (4) esophagus, (5) stomach, and (6) hind gut. The oral papilla marks its anterior termination and serves as an upper lip for the mouth, the actual mouth opening being a transverse slit leading into the pharynx from the posterior edge of the papilla.

The pharynx below the mouth is 0.02 mm in diameter and extends up and inward for a distance of 0.03 mm. Its walls consist of a layer of epithelial cells lying beneath the cuticle and a number of muscular fiber bands. W. Baldwin

Spencer has suggested that the oral papilla is used by the parasite as a rasping organ, and that the pharyngeal muscles are employed to extend or withdraw it from the mouth opening. The fiber bands connect with the oral papilla and the border of the mouth. Leading away from the pharynx is a narrow tube like esophagus 0.018 mm. in diameter and extending inward and down for a distance of 0.13 mm. The layer of epithelial cells is continuous with that of the pharynx. Light bands of both circular and longitudinal muscle fibers are present in the esophagus and the cuticle here becomes extremely thin. Toward its posterior end, it widens rapidly and leads into the stomach cavity. This is the widest portion of the alimentary tract, and attains a diameter of 0.15 mm. in some of the larger specimens. The length of the stomach is 0.5 mm. and the histological structure is quite similar to that of the esophagus, but here the epithelial layer is thinner and the cuticle wider. Coagulum is nearly always present thruout the length of the stomach. Leading from the stomach is the hind gut, which is quite uniform in size for the greater part of its length. It is 0.08 mm. in diameter for a distance of 1.6 mm. and then narrows to an average diameter of 0.52 mm. for the remainder of its length. The columnar epithelium of the hind gut extends out further towards the center of the intestine than it does in the esophagus or stomach. A characteristic feature of the hind gut is its lateral turning and twisting. The bending stops however, as the posterior end is approached except for a short turn that

leads to the anal opening. Accompanying the intestine, from a point near the head region, are two large cellular masses. The intestine is wedged between and connected with them by a light mesentery on either side. The glandular bodies are the hook glands.

The Nervous System. The nervous system consists of a central ganglionic mass, ventral to the lower end of the esophagus and two pairs of nerves given off from its upper and lower margins. The anterior pair leads directly to the primary papillae and end at the tip passing upward thru the center of the primary papillae. The posterior nerves extend well toward the caudal end of the body and lie on the ventral side of the body cavity closely approximate to the oblique fibers. The latter nerves are present in all cross sections of the body posterior to the beginning of the stomach. In allied species, Stiles, Leuckart and Spencer have described a delicate circumesophageal ring and additional nerves branching from the main nerve mass. The writer was not able to locate the above mentioned structures in any of the sections available.

Reproductive System. A study of the male reproductive organs shows them to be in an undeveloped condition. They represent one of the early stages that Leuckart has thoroughly described in *Pentastomum taenioides* (L. serrata). He terms it the "Fifteenth Month" stage. The atrium genitale or genital aperture marks the anterior termination of the system. It is the junction point of the two seminal tubes which branch out and extend posteriorly. They lie anterior

and ventrad of the hind gut and approach in an oblique direction to two bag like structures which are directly ventrad of the hind gut. Each tube is 0.33 mm. in length and composed of an inner wall of cells arranged in a single layer and an outside covering of transverse and longitudinal muscle fibers. On either side, the tube enters a rounded structure, which is divided into upper and lower portions. The upper portion is not as large as the lower part in this stage. It develops more rapidly later and pushes the lower pouch inwardly. The upper is known as the cirrus pouch or sac and contains the cirrus, in the mature forms. The seminal tube also enters the cavity of the lower pouch which is called the dilator rod sac. The rod sac appears somewhat larger than the cirrus pouch. The lining of the two cavities is similar. A row of epithelial cells covers the muscular wall of each vessel and lines the cirrus bulb, a canal extending posteriorly from the dilator rod sac. The cirrus bulb is only the widening of a tube, the vas deferens, with which it is continuous. The vas deferens is 0.25 mm. in length and its structure is that of a narrow canal with the walls lined on either side with several rows of small epithelial cells. At the end of this tube, the ejaculatory duct branches to the side and the vesicula seminalis continues as the principal prolongation of the vas deferens. The ejaculatory duct is 0.43 mm. long, cylindrical in shape, and ends in a round cone. The wall of the duct is thick and muscular and stands out quite plainly in a surface view of the body. Immediately outside of the wall is a narrow row of rounded epithelial cells. The

purpose of the duct is to aid in the expulsion of the cirrus. The pair of seminal vesicles meet just dorsal to the hind gut and enter the testis. The alimentary tract extends thru the ring formed by the two branches of the genital system, at a point about 0.2 mm. anterior to the beginning of the testis. The testis is a long narrow unpaired tube extending a little more than half the length of the body and lying dorsal to the hind gut. In mature specimens, it is flattened along its whole length except at the extreme anterior end. And in older specimens it is much larger, often taking up more space in the body cavity than the intestine. The material within the mature testis consists of numerous cells of doubtful origin scattered here and there, which are much larger than the cells of the testis' wall. In a few specimens bands or sheathes of sperms are present between the cells, but in most cases no sperms were evident. The wall of the testis is composed of a minute outer membrane and an inner double row of deeply stained cells which have large nuclei

V. THE ENCYSTED LARVA

In the material, some of the specimens are enclosed in a very thin elastic membrane which covers the body completely. The membrane is composed of connective tissue and is quite transparent so that the form of the body and even the outline of the hook glands are easily seen thru it. The marks of the annuli are just faintly noticeable. The cyst, formed by the membrane is 1.52 mm. in diameter and the parasite lies coiled on itself. A circle is thus formed by the body but the anterior tip of the cephalothorax does not quite come into contact with the posterior end of the abdomen. The body lies on its lateral edge with the ventral surface out and the dorsal surface is bent and forms the circumference of the inner circle. In some cases the posterior end of the body lies a little within the cephalothorax and here the central cavity is not so large. Examination of the larva shows the presence of the characteristic double hooks and the same number of annulations as in the free parasite. There is no apparent difference between the two states except the encysted form measures slightly less than the average length of the free larva. The internal anatomy of the two larval types agree in all points.

VI. LIFE HISTORY

As in other parasitic forms the problem of development in the Linguatulidae is rather complex. Chiefly thru the researches of van Beneden, Leuckart and Stiles have the life histories of a very few species been worked out. In 1848, van Beneden was able to observe the development of *Linguatula diesingii* (*P. crotali*) and trace its life history. Leuckart later made a more complete study of *Pentastomum taenioides* (*L. serrata*) and proved *Pentastomum denticulatum* the larval stage. Stiles 1891 worked further on *P. proboscideum* (*P. crotali*) while Neumann 1899 has conducted experiments with *P. armillatus* from the African python, *Python sebae*.

The life cycle of the parasite is divided into two periods, the adult and the larval period. However, many recognize several larval stages. The adult stage is usually found in the lung of snakes and other reptiles with the exception of a very few species. *L. serrata* for instance, has its adult stage in the nasal cavities of carnivora. The larval stages are most commonly found in herbivorous animals, but here again we have exceptions to the rule. The larval stage of *P. armillatus* has been found in a number of carnivora. Sambon thinks that the larger mammals are only accidental hosts and that the life cycle can not there be normally be continued. Encystment follows similar to that of bladder worms and the larval cysts of tape worms. The final result is the calcification of the cyst. But this is not always what happens.

Larvae when not liberated from their cysts often begin a migration probably in an effort to reach the adult host. This migration may cause grave symptoms in the host for the presence of the larvae favors secondary bacterial infection. Too, their position and number may be such as to further menace the life of the larval host.

The ova which may be as many as half a million are laid by the adult female in the nasal cavities of the host. They are either discharged thru the mouth or pass thru the alimentary canal with the snake's excretions. In the case of dogs, they are sneezed from the nostrils. The intermediary host becomes infected in one of three ways, (1) by swallowing embryos with or in the food, (2) thru drinking water, (3) by coming into direct contact with the ova. The ova are very resistant to climatic conditions. Stiles placed a number of eggs in a moist chamber for forty nine days and then succeeded in infecting mice. Broden and Rodhain has a similar experience. They kept the eggs of *P. armillatus* in water for three months and then were able to successfully infect animals. Two dogs in Neumann's laboratory were accidentally infected with linguatulid eggs from the *Python sebae*. The pythons had been dissected in the yard of the laboratory several months previous to the birth of the dogs. The ova therefore had been lying in the yard for many weeks, perhaps under severe weather conditions. Still they were able to infect the dogs.

In the intermediary host, the ovum after passing into the alimentary tract comes into contact with the gastric juice of the intestine and the shell covering is dissolved away. The four legged embryo becoming free attaches itself to the wall of the intestine and after a short period of growth, pierces thru the mucosa of the intestinal tract. If it happens to reach a lymph vessel, it makes its way to the mesenteric glands or else is carried thru the ductus thoracicus to the right heart and lungs. However, if the embryo comes into contact with the blood vessels of the intestine, it is transported to the venae porta and the liver. When the embryo comes to rest, a cyst is produced by the host. Here growth continues slowly until the embryo escapes from its cyst in the body of the adult host or else calcification takes place. Under certain conditions, a migration from the larval host takes place and the parasites attempt to escape.

Certain species have only been found in the larval stage, while other forms are known to be present in both the larval and adult state in a single host. An example of the complete development without a secondary host is found in *P. oxycephalus* where the two stages occur in the lungs of the alligator. The larva and the adult of *L. serrata* are both found in man. It is therefore probable that for some species, an intermediate host is not necessary in order to complete the life cycle.

VII. SYSTEMATIC POSITION AND CLASSIFICATION.

In trying to identify some linguatulids, Shipley found great difficulty in arriving at any clear idea of the existing species of the family. He consequently published (1898) his paper entitled "An Attempt to Revise the Family Linguatulidae", in which he has sought to bring together all previously described species under his classification. In this paper, he raised the subgenera *Linguatula* and *Porocephalus* to genera as Hoyle had suggested. In describing the different species, he has given Leuckart's diagnosis in many cases because of the latter's valuable systematic work in the case of some forms where the authors description was incomplete. Since Shipley's paper, two new genera have been added to the family and many new species described. Sambon has also cleared up many points of difficulty with regard to synonymous forms. The writer has endeavored to review the original descriptions of as many species as possible. Using these and the papers of Shipley Sambon as a basis, the following key and classification of the known species of the family Linguatulidae is presented.

Porocephalus crocidili has recently been described by Wheeler (1915) from the crocodile of Ecuador. The diagnosis of this species is omitted because Wheeler's paper has not been available.

Raillietiella boulengeri Sambon which is considered by some as a doubtful species, is included, altho without a complete description of the form.

- 28 (32) Annuli less than 35.
- 28 (30) Annuli 16-26.
- 28 (29) Annuli 16-22..... P. armillatus
- 29 Annuli 22-26..... P. grandis
- 30 (31) Annuli 20-30, groove between cephalothorax and abdomen
..... .. P. annulatus
- 31 Annuli 26-33..... .. P. moniliformis
- 32 (33) Annuli 35-45... .. P. clavatus
- 33 (35) Annuli 45-55.
- 33 (34) Annuli 50, hooks simple..... P. globicephalus
- 34 Annuli 45-52, outer hooks double.....
P. stilesi
- 35 (36) Annuli 65-70..... P. teretiusculus
- 36 Annuli 80 or more.....
- 36 (37) Mouth on line with hooks.... P. crotali
- 37 Mouth anterior to hooks.... P. lari

Diagnoses of the Known Species of Linguatulidae.

(1) *Linguatula pusilla* Diesing 1836.

Body long, attenuated posteriorly, ventral part slightly flattened, sub-elliptical, dorsum slightly convex, above and below the margins evidently folded transversely. Head truncated; mouth round, between the two muscle plates which are vertical, converging backwards. Bothria arranged in an arc, provided with simple hooks. Length $1\frac{1}{2}$ ", width $\frac{3}{4}$ ". (Leuckart) One of the smallest linguatulids.

Habitat. In the intestine of *Acara coscudo* from South America.

(2) *L. recurvata* Diesing 1836.

Body lance shaped, posteriorly attenuate and recurved, emarginate at the caudal apex, ventral surface slightly flat, dorsal convex, folded in ring fashion at the margins. Head truncate; mouth elliptical, placed between the arcs of the bothria sheathing simple hooks. Length of female 18-27 mm. (Leuckart) Easily distinguished from *L. serrata* by the bifid tail which is always bent backwards.

Habitat. Frontal sinuses and trachea of *Felis onca*. Heart of peccary, *Dicotyles labiatus* from Brazil.

(3) *L. subtriquetra* Diesing 1836.

Body subtriangular, slightly flattened ventrally, subelliptical and ovate-oblong, folded transversely, margins crenate. Dorsal sides slightly convex. Head truncate, mouth orbicular, placed in the middle between the four oblique ventral ribs. Bothria arranged in an arc. Length of female 6.7 mm. (Leuckart)

Habitat. Throat and lungs of *Crocodilus sclerops* Gray from South America. Also in the pharynx of the Indian crocodile.

(4) *L. serrata* Froelich 1789.

Adult. Body lanceolate, posteriorly attenuate, postero-ventral part slightly flat. Head rounded destitute of marks, cephalothorax not very distinct. Annuli about 90, single series of stigmata arranged at intervals in the median line. Hooks perceptibly acuminate, adhering by an elongate fulcrum, sharply recurved. Female 80-100 mm. in length, width at the anterior part of the body 8-10 mm., at the posterior part 2 mm. Male 18-20 mm. long, width 3 mm. at the anterior part and 0.5 mm. at the posterior part. (Leuckart)

Habitat. In the frontal sinuses of *Canis familiaris*, *Equus caballus*, *Felis onca*, and the nasal cavities of *Canis vulpes*, *Capra* sp., *Homo sapiens*, *Ovis aries*, and the mule.

Larva of *L. serrata*. Annuli dentate, accessory hook with boat shaped termination, small end quite sharp. (Leuckart)

Habitat. In the liver and mesenteric glands of *Capra* sp.; the liver and lungs of the cat, and *Cavia cutleri*; the liver of *Equus caballus*; the lungs, mesenteric glands and intestine of *Bos taurus*; the lungs of *Hystrix cristata*, *Lepus cuniculus*, and *L. timidus*; the mesenteric glands of *Camelus* sp., *Ovis aries*, *Alcelaphus bulbalinus*, *Cervus dama*, and *Mus decumanus*; the liver, connective tissue, spleen, kidneys and mesenteric glands of *Homo sapiens*. In the last named host it has been reported from Brazil, Panama and many European countries.

(5) *Reighardia sterna* Ward 1899.

Body devoid of annulations, poorly developed hooks.

Habitat. Air sacs of the Bonapartes gull and the common tern, North America.

(6) *R. indicus* (v. Linstow) Sambon 1910.

Only females have been found. Rather young specimens are 20 mm. long and 2 mm. broad; behind the thin anterior end the body is thickened and spindle shaped, attaining a width of 1.18 mm.; behind this it contracts to a narrow neck 0.79 mm. in diameter; older animals are 24 mm long and 5 mm. in diameter, the diameter here is nearly uniform. On the ventral side the cuticle is transversely ringed at regular intervals of 0.44 mm., the rings occupying three twenty thirds of the circumference; the muscle fibers run in four directions, transversely, longitudinally, and obliquely in two directions making equal angles with each other; the anterior and posterior ends are rounded. On the lateral edges of the rings there are posteriorly finger shaped prolongations, which become smaller and smaller further back, but which can be traced far backwards; exteriorly they possess an exterior chitinous covering; at the anterior end there lies beneath the cuticle an oval ring which is provided in front and behind with a prolongation and on the right and left of it with two hooks on each side which are directed forwards and outwards and the points of which project freely. Their length is 0.15 mm. The intestinal canal opens at the posterior end; the vaginal aperture is situated closely in front of the anus; the vagina is 1.1 mm. long and 0.044 mm. wide, while the width of the uterus, the numerous convolutions of which

fill the body cavity amounts to 0.16 mm.; the eggs possess a thick hyaline envelop, they are 0.052 mm. long by 0.044 mm. wide, the yolk attaining a length of 0.026 mm. and a width of 0.016 mm.

Habitat. In the trachea and lungs of *Gavialis gangeticus* from Asia.

- (7) *R. lohrmanni* Vaney and Sambon 1910.

Body of adult female club shaped, slightly flattened on the ventral surface; greatest width at the posterior limit of the anterior quarter, from this the body rapidly lessens in front, and more slowly behind. Length 13-17 mm. greatest breadth 3 mm. Hooks and mouth very small and closely compressed at the tip of the body. (Lohrmann)

Habitat. In the lungs of *Monitor niloticus*, *Varanus niloticus*, and in the lungs of the North African lizard *Varanus ocellatus*.

This species was described by Lohrmann in 1889 as *Pentastomum clavatum* and renamed by Sambon.

- (8) *R. platycephalus* (Lohrmann 1889) Sambon 1909.

Body of adult female almost cylindrical, greatest diameter just anterior to the hinder end. Head flat, blunt, and only slightly smaller than the body. Hooks slender, widely separated from each other, the mouth opening distinctly oval, the long axis longitudinal, situated between the anterior hooks. About 70 rings are scarcely visible. Length 23 mm., breadth 2.8 mm., hook glands consist of two glandular bodies attached to the alimentary canal. (Lohrmann)

Habitat. Unknown, perhaps in the alligator.

- (9) *Raillietiella fercocercum* (Dies. 1836) Sambon 1909.

Body subfusiform, attenuated posteriorly, bifid at the caudal end, segmented with linear rings. Head obtusely triangular, somewhat depressed. Mouth oval, has a wide margin with truncate apex and between the bothria a truncate cone obtuse trilobed in shape with double unequal hooks. Female, length 20-22 mm., width anteriorly 2.2 mm., width posteriorly 1.12 mm. (Leuckart) Annuli 40-50.

Habitat. Lungs of *Varanus ocellatus*, *Boa constrictor*, *Amphisbaena alba*, mesentery of *Zamenis constrictor*, and abdominal cavity of *Drymobius bifossatus*.

- (10) *R. boulengeri* Vaney and Sambon 1910

Very similar to *R. furcocercum* but more slender. Miss Hett could find no essential difference between the two species.

- (11) *R. furcocercum* var. *mediterraneus* Hett 1915

Male 10-15 mm. in length, female 20-30 mm. in length, annuli 40-45. The body is more slender and darker than in var. *orientalis*.

Habitat. *Zamensis gemonensis*.

- (12) *R. furcocercum* var. *orientalis* Hett 1915.

Length 30-40 mm., annuli 40 or more, mouth oval. Anterior end of cephalothorax more rounded and the body more slender than in *R. furcocercum*.

Habitat. *Zamensis mucosus* and *Naia tripudians*.

- (13) *R. geckonis* Dujardin 1845.

Body fusiform, posteriorly attenuated, bifid caudal tip, segmented. Head triangular, hooks simple, unequal, posterior ones twice as large as anterior. Female, length 16-18 mm., width 1.6-1.8 mm. (Leuckart)

Habitat. Lungs of the Siamese gecko, *Gecko verticillatus*.

- (14) *Porocephalus najae sputatricis* Leuckart 1860.

Body in larval stage cylindrical, posteriorly attenuated, acuminate. Cephalothorax hardly distinguishable, rounded at the front. Rings about 50, very short, serrated, perforated by two rows of stigmata arranged alternately. Hooks in pairs, unequal, the accessory being small. The principal hook is barb shaped, fulcrum wide, rather short, rounded; anterior hooks smaller than posterior; points of barbs curve nearly to the base. Length 4.5 mm., width 0.6 mm. (Leuckart) The adult stage is unknown.

Habitat. Abdominal muscles and peritoneum of *Naja tripudians*.

(15) *Porocephalus heterodontis* Leuckart 1860.

Species observed only in the larval stage. Cylindrical body, posteriorly attenuate, anteriorly clavate; front round; annuli 58, very narrow, fringed. Stigmata form a single series of openings. Hooks double, unequal, upper more slender, lower broader and sharply curved; basal hook broad, elongate, round. Length 6.3 mm., width 0.65 mm. (Leuckart).

Habitat. Encysted in the abdominal muscles and peritoneum of *Heterodon* sp. The writer reports this species for the first time from the water moccasin *Ancistrodon piscivorus*.

(16) *P. pattoni* Stephens 1908.

Body grayish white (spirit specimens), showing a separation into head, neck and body. The head is globular, flattened ventrally and rounded dorsally, and is separated from the body by a fairly distinct narrow neck. Of some dozen specimens the longest was 11.5 cm. while the shortest was 2.5 cm., the majority measured 6-8 cm. in length. The number of rings varies somewhat but averages 36. There are generally 2 rings on the head. The body is cylindrical, ends bluntly, and the posterior end exhibits some torsion. The thickness of the body is about 2.5 mm. On the ventral surface of the head are two pairs of strongly curved hooks, similar to those of many other linguatulids. In front of the mouth hooks there are several small papillae, corresponding in position to the continuation of the clefts that contain the hooks. Between the hooks lies the chitinous opening of the mouth which has the shape of a horse collar. Cutaneous pores are abundant on the head and on the ridges of the anterior part of the body, they then become indistinct and few are visible on the last segments. Eggs taken from the uterus measure 70 by 80 micra. (Stephens) 2

Habitat. In the lungs of the Indian rat snake, *Zamenis V. Ptyas mucosus* or *Dhaman*.

(17) *P. wardi* Sambon 1909.

Length 7-13 mm., annuli 45. In form and general appearance resembles *P. crotali*. Larval form.

Habitat. Abdominal cavity of the great Teju or common Teguxin, *Tupinambis teguxin* from South America.

(18) *P. kachugensis* Shipley 1910.

Specimens vary from 9-12 mm. in length. Body club shaped, thicker anteriorly. The thicker anterior end is 3-3.5 mm. from back to front, and 3-4 mm. from side to side. The body tapers somewhat suddenly and the posterior two thirds is from 1-1.7 mm. in breadth and a little less in depth. In their cysts the animals are coiled like a note of interrogation and the coil is always in one plane. Anteriorly the head bears a pair of well marked rounded papillae which project forward. The mouth is small and is placed at about the level of the inner hooks which are slightly in front of those of the outer hooks. All four hooks project rather further than in most pentastomids and they are very markedly double. The number of annulations is 40-41. At both ends, but particularly at the anterior end, the lines marking the annulations are very faint, and it is difficult to decide exactly where the first begins and the last ends. There are no internal organs serially homologous with the annulations. The annulations are confined to the ventral surface, they cease suddenly a little way up each side of the body and seen from the dorsal surface, the animal is smooth and not ringed. (Shipley).

The demarcating lines between the annulations are made more prominent by bearing a row of 150-160 chitinous rods, somewhat sabre shaped. There is a slight median ventral groove.

Habitat. In the liver of *Kachuga lineata* Gray, one of the Indian and Burmese representatives of the family Testudinidae.

(19) *P. coarctatum* (Dies. 1850) Sambon 1910.

Head constricted at the base, subhemispherical, ventral side slightly flat, body heavily segmented with annuli. (Diesing) Annuli 50-55.

Habitat. Lungs of *Drymobius bifossatus*, *Coluber carais*. Except in the number of annulations this species resembles *P. pattoni*.

(20) *P. crocidura* Parona 1890.

Cylindrical body, slightly tapering behind. Length 10.5 mm., breadth thruout anterior end of body 1 mm. Body divided into 62 regular annuli, which slightly diminish in length posteriorly. The anterior end of the body for the length of five annuli is flattened and bears two papillae. The mouth is surrounded by a chitinous ring and four double hooks. Each annulus bears two or three rows of cutaneous pores. The posterior end has a groove which gives it a bilobed appearance. The hooks are on a line with the mouth. (Parona)

Habitat. In the peritoneum of Blyth's musk shrew, *Crocidura fuliginosa* from Burmah.

(21) *P. megastomus* Diesing 1836.

Body clavate, attenuately recurved, pointed, folded with linear rings, muscle plates. Length of female 11 mm., anterior width 2.2 mm., posterior width 0.7 mm.

Habitat. Lungs of *Hydraspis geoffroyana*.

(22) *P. gracilis* Diesing 1836.

Body slender in larval form, worm like, rings plicate, ventral surface slightly flattened. Cephalothorax clavate, truncate, quite distinct, annuli 90, anterior narrow, posterior very narrow, border of body dentate. Stigmata collected together into four or five series, alternately disposed. Hooks elongate, two pronged, subequal, accessories joined closely with the main hook. Base broad, elongate, circular. Length 11 mm., width 1.7 mm. Adult stage unknown. (Leuckart)

Habitat. Free in the body cavity or encapsuled in the viscera or mesenteries or muscles of the following South American fishes and reptiles. Fishes listed by Parona; *Acara crassipinnis* (*Hydrogonus ocellatus*), *Bagrus pemecus* (*Arius* sp.), *Bagrus mesops* (*Arius hertzbergi* and *A. mesops*), *Macrodon trahira*, *Salminus brevidens*, *Tetragonopterus argenteus*, *Pygocentrus piraya* (*Serrasalmo piraya*), *Raphiodon vulpinus* (*Cynodon vulpinus*), *Pimelodus megacephalus*, *P. vituga*, *P. pirinampus* (*P. typus*), *Phractocephalus hemilopterus*, *Platystoma tigrinum*, *P. platyrhynchus* (*Hemisorubim platyrhynchus*), *Pellona castelleana* (*P. flavipinnis*), *Symbranchus marmoratus*, *Gymnotus electricus*, *Carabus brachyurus* (*G. fasciatus*), *Sternarchus albifrons* and *Taeniura motoro*. Reptiles listed by Diesing; *Podinema teguixin* (*Tupinambis teguixin*), *Podinema* sp., *Bothrops juraraca* (*Lachesis lanceolatus*), *Elaps* sp., *Pseuderis* sp., *Tropidonotus* sp., *Coluber* sp., *Eunectes scytale* (*E. murinus*). It has also been taken from the intestine of *Alligator mississippiensis*, the North American alligator. This species appears to be very common in Brazil. The Diesing collection in the Natural History Museum of Vienna contains over 40 vials of these forms, collected by Natterer. About one half the specimens are one half the size given in the diagnosis.

(23) *P. subuliferus* Leuckart 1860.

Body cylindrical, clavate at the ends, obtuse, segmented, cephalothorax very distinct, ventral part slightly flat. Rings about 40, short, slightly prominent, stigmata arranged in two irregular series. Hooks unequal, posterior double, anterior large single very short fulcrum wide, incurved, barb large, strong and distinguished by circular depression at the basal part. Accessory hook slender. Length 26 mm., width 1.5 mm. (Leuckart)

Samson has found immature specimens to measure 9-15 mm. in length. The head is separated from the abdomen by a complete groove. There is a midventral line and the outer hooks are double. Annuli 40-50.

Habitat. Adult. Lungs of gaboon puff adder, *Bitis gabonica*, and lungs of Egyptian cobra, *Naja haje*. Type specimens in the museum of the Liverpool School of Tropical Medicine.

(24) *P. megacephalus* Baird 1853.

Female, body yellowish white, somewhat depressed and terminating anteriorly in a large thick club shaped head. Dorsal surface depressed at the edges, rounded and very prominent in the center and transversely ridged. Ventral surface is more flattened, ridged and wrinkled, with the mouth in a hollow depression, surrounded by four strong, brown simple hooks. The part of the body immediately beneath the head is very strongly ridged transversely, each of the first six six ridges wavyly wrinkled. Length 11 lines. Head is five lines broad, and the middle portion of the body about 3.5 lines long, diminishing in size toward the tail. The oviduct is very long, the portion outside of the body being two inches in length.

Male, length 14 lines, covered with a smooth skin which is slightly ridged across, and has at its anterior extremity a small sharp papilla about $\frac{3}{4}$ line in length and brown at the tip (the penis?). The inferior extremity is rounded more than in the female, but otherwise they are alike. (Baird) Annuli 40-50.

Habitat. In flesh of head of soonderbund crocodile, *Crocodilus palustris* from India.

(25) *P. seurati* Neveu-Lemaire 1900.

Body cylindrical, tapering gradually toward the posterior end. Cephalothorax distinct and much wider than the rest of the body. Hooks unequal. The anterior pair are further out from the median line, mouth between and a little below the posterior pair. The mouth is in the form

of a circular depression, in the background of which there appears a horn like armature. The abdomen is formed of 60 annuli, distinctly separated from each other, and extending to the posterior termination which is round. (Neuveu-Lemaire) Total length, 24 mm., length of cephalothorax 2 mm., width of cephalothorax $2\frac{1}{2}$ mm., average width of body $1\frac{1}{2}$ mm., width of posterior end $\frac{3}{4}$ mm.

Habitat. Underneath the skin in the superficial muscles of *Elaps fulvius* L. from Guatemala

(26) *P. oxycephalus* Diesing 1836.

Body cylindrical, straight or (in the smaller ones) incurved, ring folded, folds disappearing with increasing size. Cephalothorax very slightly distinct, anterior region acuminate, truncate rather prominent front. Width of abdomen posteriorly decreasing in the smaller and increasing in the larger forms. Anal extremity truncate. Rings about 60, short lengthwise, provided with a single series of stigmata. Curvature of barbs approaches to base, apex almost straight; basal part in smaller specimens inflated, spined, in the largest, entire. Fulcrum wide elongated, rounded, orifice of mouth narrow. Length of female up to 25 mm., maximum width 3.4 mm. Male much smaller, length 10 mm., width anteriorly 1.7 mm and posteriorly 1 mm.

Larval stage. Body slender subfusiform, incurved, hooks double, fringes at the posterior margin of annuli. Slender barb shaped accessory hook. Spines slender, rather short, widely separated from each other, entirely absent on the posterior part of the body. Length 7 mm., width 0.8 mm. (Leuckart)

Habitat. Adult and larva. In the lungs of *Crocodilus americanus*, *Caiman latirostris* and *C. sclerops*; and in the lungs and liver of *Alligator mississippiensis*.

(27) *P. tortus* Shipley 1898.

The young form is very distinctly ringed, the number of rings is 25. In the mature forms the development of the genital organs have so stretched the skin that the rings have disappeared, and at the same time the body has become curiously twisted. This characteristic feature has suggested the specific name of the form. The cephalothorax which includes the first three or four rings, is well marked off from the rest of the body. The rings as the body stretches, disappear lastly from the region behind the well marked neck. The hooks are single, the inner pair slightly in advance of the outer. The mouth is almost oval and a little posterior to the inner hooks, a chitinous half cylinder runs back from it along the posterior face of the esophagus. The length of the mature female is 40 mm.,

the head is 5 mm. long. The width of the body is very constant behind the neck, tapering only slightly toward the tail, it is 2.5-3 mm. The length of the immature female is 35 mm., length of the young form 10 mm., breadth 1 mm. (Shipley).

Habitat. *Dipsamorphus irregularis*, from New Britain.

(28) *P. armillatus* Wyman 1847.

Body thick, wide, transversely ridged, cephalothorax not very distinct, rounded anteriorly, abdominal rings 19 all except the last equal in width, funnel shaped, posterior margin prominent and raised. Anal ring conical, acuminate. Female length 70 mm., width 6.7 mm. Male unknown. Larval stage probably is *Pent. diesingi* van Beneden from the peritoneum of *Cynocephalus maimon*, in capsules. Shape of body and number of rings agree, it differs only in size, being 15 mm. long by 2.5 mm. wide. Raised stigmata crowded closely and are dispersed in irregular series of eight or nine in a row. Margin of rings prominently dentate; no accessory hook. Fulcrum somewhat short, wide, truncated posteriorly. (Leuckart)

Additional characters noted by Sambon. Annuli 16-22, length 9-13 cm., width 5-9 mm. He described the male as 3-4.5 cm. in length and 3-4 mm. in width. No difference between cephalic and abdominal regions. Two prominent papillae above the inner hook pits, one above each. Other small papillae below the inner hook pits, above and below the outer hook pits, and at the back and side of the cephalothorax. In the female the vagina lies 2 mm. anterior to the posterior end of the terminal cone. The male reproductive opening is in the midventral line, on the first anterior annulus. The nymphal form resembles the adult and has been found only in mammals.

Habitat. This is the most common linguatulid of the African region, and the larval form has been found in the natives of North and Central Africa. Adult found in *Bitis gabonica* Dum. and Bibr., the gaboon puff adder; *B. nasicornis* Shaw, the horned puff adder; *B. arietans* Merrem; *Python sebae* Gm. of West Africa; and *P. regius* Shaw, the royal python. Larvae found in the liver of *Homo sapiens* and mesentery of *Macacus*; in the liver, spleen, intestine, stomach, peritonuem, mesentery and uterus of the common antelope, *Tragilaphus scriptus*, and in the antelope, *Cephalopus leucogaster*; it also is reported from *Cricetomys gambianus*, the Gambian pouched rat; *Cerropithicus engythia*; *Papio sphinx* L., the Guinea baboon; *Perodicticus potto* Gm.; *Crossarchus obscurus*; *Cervicapra arundinum* Bodd., the South African Reed buck; *Camelopardalis giraffa* L.; *Papio marmon*, the mandrill; *Cercopithecus albigularis* Sykes,

Anthropopithicus troglodytes Gm., the chimpanzee; *Cercopithecus pousarguei*; *Cercocebus fuliginosus* Geoffr., the sooty mangabey; *Erinaceus aethiopicus*, the African hedgehog; *Crossarchus fasciatus* Desm., the banded ichneumon; *Proteles cristatus* Sparrm., the aard wolf; and *Felis leo* L.

(29) *P. grandis* Hett 1915.

Body cylindrical, tapering toward the posterior end; 22-26 annuli, not sharply defined. Hooks simple and together with the mouth lie in a pit bordered by papillae. Mouth circular. The posterior annulus is small, conical, and bears the transverse anus. Stigmata over the entire body surface. Small lobe in front of the mouth. Slight projection in the median line of the postero-ventral margin of each annulus. Male 30 mm. in length, female 82 mm. in length. Male genital opening directly in front of the anus on the posterior segment.

Habitat. In African vipers; *Bitis gabonica*, *Cerastes cornutus* and *Bitis nasicornis*.

(30) *P. annulatus* Baird 1853.

Body elongate, cylindrical, ribbed transversely in adult females, cephalothorax clavate, rounded anteriorly, abdomen made up of 20-30 rings. Stigmata are found placed close together over almost the entire surface of the rings forming eight to eleven series diminishing perceptibly posteriorly. Fulcrum wide, somewhat short, truncated posteriorly. Length of female up to 94 mm., width 4-5 mm. Smaller examples, 15-20 mm. long and 1.8-2.3 mm. wide. They have bands of rings which are hardly so prominent. Male forms agree in shape and size with the smaller females. (Leuckart). The annuli are separated from the head by a distinct groove.

Habitat. Adult in the lungs of the Egyptian cobra, *Naja haje*. Larvae in the gray headed gallinule *Porphyrio porphyrio*, and the demoiselle crane, *Anthropoides virgo* from North Africa.

(31) *P. moniliformis*

Body thick tapering posteriorly, caudal extremity acuminate, contracted in moniliform fashion. Annuli 26-33. Male, length 18-25 mm., width 1.8-2.5 mm. Genital opening is in the anterior midventral line of the first annulus. Female, length 70-91 mm., width 4-7 mm. Genital opening on terminal cone, 1 mm. from the anus.

Habitat. In the lungs of the Indian python, *Python molurus* L., and the netted python, *P. reticulatus* Schneid. from Malay.

Larva of *P. moniliformis*.

Specimens 17-20 mm. in length, straight, elongate, acuminate, with nearly conical apex and an obtusely truncated head which is 2.5 mm. in width. It is closely annulated with 30 rings, each of which is sharply defined and separated from its neighbors by a sharp edged, square profiled furrow. These rings from being very wide posteriorly (0.7 mm), become very narrow in front and cease to be distinct at the head. The mouth has two lateral chitinous lip ridges, one on each side. The two pairs of hooks are elongate, acute, with longer basal fulcra than in *P. crotali* (four times the length of the exerted portion of the hook), but with a much shorter basal process. The surface of the skin is covered over with numerous irregularly arranged circular dots with depressed edges, these are most numerous about the head and forepart, but become fewer posteriorly. (Macalister).

Habitat. In the peritoneal cavity of the large Indian otter, *Lutra noir*, from the river Indus. The larva has been reported also from the liver of *H. sapiens* from the Philippine Is., the small intestine of *H. sapiens* from the Dutch Indies, and the submucous tissue of the jejunum of *H. sapiens* from India. It occurs in the mesentery, spleen, omentum and gall bladder of the Indian civet, *Viverricula malaccensis* Gm.; in the peritonuem and omentum of the macque monkey, *Macacus cynomologus* from Indo-China and in the rhesus monkey, *M. rhesus* Aud.

(32) ***P. clavatus* Wyman 1845.**

Adult yellow tinged during life and gray white when preserved. Body claviform, elongate and more or less recurved. Anterior extremity rounded, somewhat flattened ventrally, and strikingly gibbous on the dorsal aspect. The tapering posterior portion terminates with a slight bulb like conical expansion. Cephalothorax 1.5-2 mm. long, rounded anteriorly, slightly convex, flat or concave on the ventral surface, prominently convex on the dorsal surface. Mouth oval. Hooks equal in size, sharply recurved and with robust points, longitudinally striated and $\frac{1}{2}$ mm. long. Inner hooks simple, outer hooks provided with accessory spike. Annuli 35-45. Female 45-90 mm. in length, 1.27-4.5 mm. in width. Anal and genital orifices open conjointly in a subterminal slit on the midventral surface, with its long axis transverse to that of the body. Male, length 19-40 mm., width 1.3-3 mm. Genital opening on the first or second anterior annulus, forming a cone on the midventral

surface which is tipped with three papillae, two anterior and one posterior.

Habitat. In the lungs, trachea, and body cavity of *Boa constrictor* L., and lungs and body cavity of *Boa imperator* from Central and South America.

Larval form of *P. clavatus*.

Body subcylindrical, curved one third or one half a circle, dorsum convex, ventrum concave, posteriorly rounded and constricted a short distance from the rounded extremity. Color white, opaque. Composed of forty or fewer annuli. Head posteriorly convex, anteriorly plain or slightly concave; mouth nearly round; hooks simple, situated in a curved line of which the mouth forms the center. Whole length 3-5 lines, breadth three fifths of a line; annuli generally one eightieth of an inch wide; mouth one two hundredth of an inch in diameter; hooks one twohundredth of an inch long.

Habitat. Encysted in the liver of the Virginia opossum, *Didelphys virginiana* Shaw, and the philander opossum *Philander philander* L.

(33) *P. globicephalus* Hett 1915.

Female 50 mm. long and has 50 annuli. Hooks simple and sharply curved. Mouth pear shaped with pointed anterior end. Head globular and divided from the body by a well marked neck. Anus is a wide transverse slit on the terminal segment. Greatly resembles *P. pattoni* Stephens, differs in number of annuli and position of anus.

Habitat. *Tropidonotus fasciatus*, North American water mocassin.

(34) *P. stilesi* Sambon 1909.

Greatly resembles *P. crotali* and *P. clavatus* in general form and appearance, but the posterior terminal ending is more rounded and the body is more uniform in diameter. Annuli 45-52. Outer hooks measure $\frac{1}{2}$ mm. in length and are provided with a straight pointed accessory spine. The inner ones are simple and slightly larger. The mouth is ovoid with the narrow end foremost. Female 80-96 mm., width 4-6 mm. On the midventral line there is a subterminal transverse slit 1 mm. in length for the genital and anal openings. Male length 30-38 mm., width $1\frac{1}{2}$ -4 mm. Genital opening in the first annulus.

Habitat. Central and South America. Lungs and body

cavity of the bush master, *Lachesis mutus*, and the rat tailed pit viper, *L. lanceolatus*. The larval form is unknown.

(35) *P. teretiusculus* Baird 1862.

Head round and truncate, body cylindrical, of a red color, and considerably more attenuated posteriorly. Tail shortly bilobed; greatest width of body about 4-5 lines below the head. It then gradually attenuates until it reaches the posterior extremity. Integument annulosely ringed, rings about one third of a line in width. Length 2 inches five lines, breadth three lines. (Baird) Immature females measure 12 mm. in length; annuli 60-70; anterior half of each annulus is spotted, posterior half not; mouth triangular with folded corners; primary papillae two, anterior to inner hooks, secondary papillae seven pairs, three dorsal, two lateral and two ventral. Male, length 13 mm., width 2 mm. Genital opening oval, with raised lip on third and fourth annulus. An eighth pair of secondary papillae lie just in front of the genital pore. The pointed tail is a feature of the genus.

Habitat. Mouth of Australian snake, *Hoplocephalus superbis* and lungs of *Pseudechys porophyriacus* and *Diemenia psammophis* var. *reticulata*, the West Australian spinifex snake.

(36) *P. crotali* Humboldt 1808.

Length of female 40-65 mm., width 2-8 mm.; the male is smaller; annuli over 80. Mouth on line with the hooks. Two prominent papillae above the oral opening. Mouth club shaped, widest at the anterior end. Tapers to the posterior end where it somewhat enlarges, and then terminates in a short conical point. (Sambon)

Habitat. Adult, *Crotalis terrificus* Laur., the dog faced rattle snake from Venezuela; *Crotalis horridus* L., the timber rattle snake; *C. terrificus* Beauvois, the diamond backed rattle snake; *Spilotes pullatus* Wagler; and *Lachesis lanceolatus* L., from Brazil. Larva in *Marmosa murina* L., the murine opossum from Brazil.

(37) *P. lari* Megnin 1883.

Cylindrical, posterior end curved, and stouter than the anterior end which tapers. Rings are marked by slight undulating striae. Two lateral and terminal tubercles on the head. Mouth oval, situated in the anterior limbs of a cross like chitinous armature. In the left angle of this cross is a small sucker like disc. The inner pair of hooks

are on the second annulus, the outer on the third. Female, length 6 cm., breadth 3 mm. Male not quite 1 cm. long and 1 mm. in diameter. (Megnin)

Habitat. In the air sacs of *Larus glaucus* Brunn from polar seas, and in the air sacs of *L. dominicanus* Licht from Bay Reo, Brazil. The larval stage is unknown, but Shipley thinks that it may reasonably be expected that its host is a fish.

The larval form of the species described by Diesing 1836 as *Pentastomum oxycephalus* resembles in a great many respects the species under observation. The two agree in the following: the number of annuli, position of the stigmata, the size, shape and arrangement of the spines, the structure and position of the hooks, the general shape and conformation of the body, the number and arrangement of the papillae, the position and structure of the mouth and genital apertures, and all points in the internal anatomy. Only in length of body is there a slight difference, Diesing's specimens being on the average a little longer. His measurement for the length of *P. oxycephalus* is 7 mm. The matter of the length, in this case, is not of great importance for the forms under discussion are probably in a more undeveloped stage than were the parasites described by Diesing. In addition, a further reason for believing the forms identical, is the fact that in both cases the alligator is the host. The specimens of Diesing are from the South American alligator but Chatin 1882 came across them in *Alligator mississippiensis*. In 1863 Wedl found a small variety *P. oxycephalus* var. *minor* in the Nile crocodile and has given a good account of its internal anatomy. Leuckart has also discussed this species to some extent. The observations of these writers has confirmed the belief that the species studied by the writer is none other than *P. oxycephalus*, now known as *Porocephalus oxycephalus* Diesing 1836.



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IX. EXPLANATION OF THE PLATES.

Explanation of Plate

Plate I.

Lateral view of mounted specimen, showing alimentary tract; x 175.



Explanation of Plate

Plate II.

Abbreviations.

a	first annulus	la	low area in cuticle
ag	atrium genitale		around mouth opening
ah	accessory hook	m	mouth
ap	anterior division of annulus	ma	mouth aperture
c	cuticle(section)	mb	chitinous mouth border
cs	cuticle(surface)	mh	main hook
extp	external protractor of hook	mop	oral papilla
exh	extensor of hook	p ₁	primary papilla
f	mouth flap	p ₂	secondary papilla
fv	frontal base of main hook	p ₃	tertiary papilla
h ₁	anterior hook	pb	inward part of frontal
h ₂	posterior hook		base
hgo	opening of hook gland duct	ph	wall of pharynx
hp	hook pit	pp	posterior division of
			annulus
		s	spine
		se	sub-cuticular epithelium
		sh	sheath covering basal
			plate

Fig. 2. Ventral view showing arrangement of papillae;
x 180.

Fig. 3. Mouth, ventral view; x 400.

Fig. 4. Lateral view of left anterior hook with part
of the attached muscles; x 400.

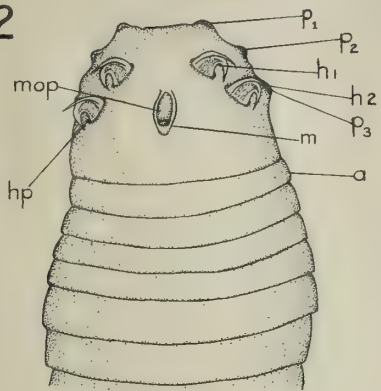
Fig. 5. Lateral view of primary papillae; x 400

Fig. 6. Lateral view of edge of body showing
divisions of the annuli; x 230

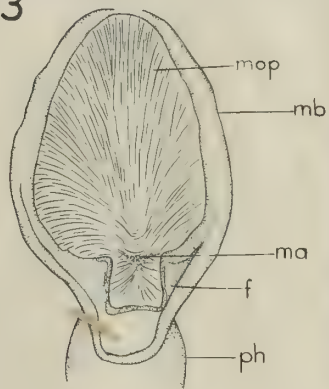
Fig. 7. Cross section of cuticle in spinous region;
x 800.

Fig. 8. Atrium genitale; x 400.

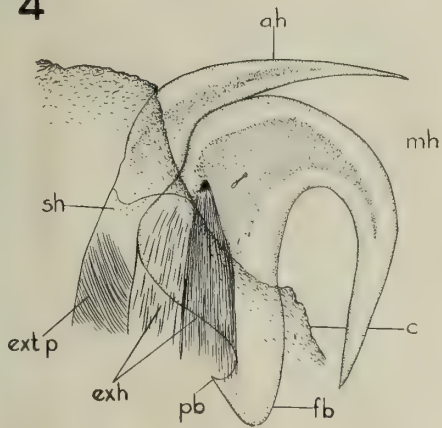
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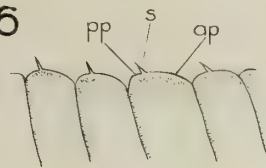
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Explanation of Plate

Plate III.

Abbreviations.

bc	border of cuticle	hm	muscles of hook
bh	base of hook	hp	hook pit
bs	basal sheath of hook	lm	longitudinal muscles
c	cuticle	om	oblique muscles
eh	extensor of hook	s	spines
gl	hook gland	se	sub-cuticular epithelium
h	hook	st	stigmata
hg	head gland	t	testes
hgd	head gland duct	tm	transverse muscle
hgt	hind gut		

Fig. 9. Cross section of head region; x 150.

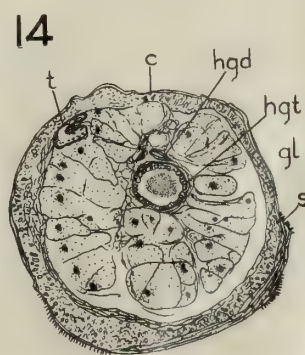
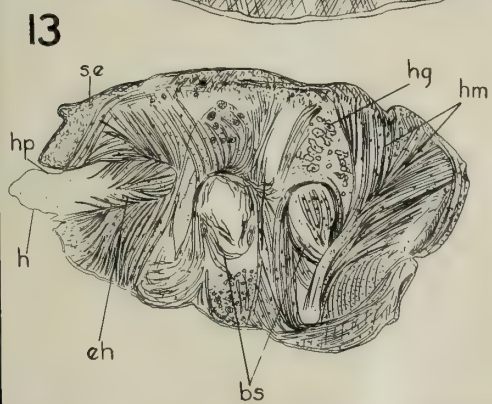
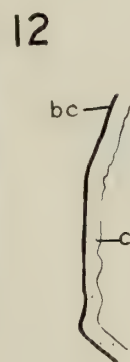
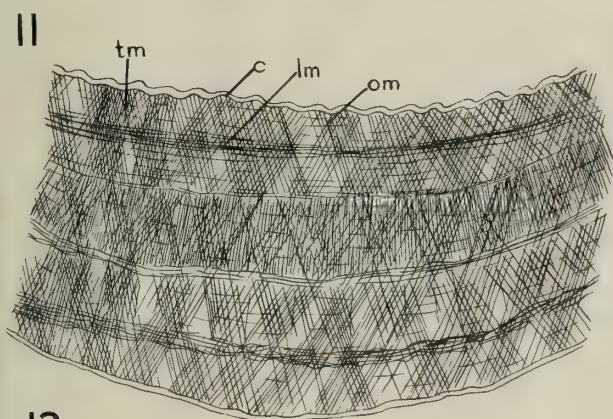
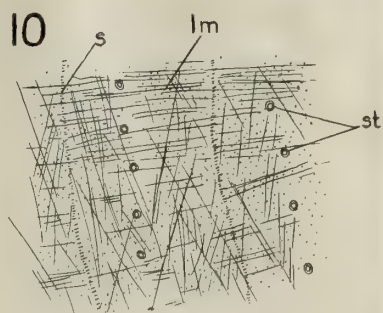
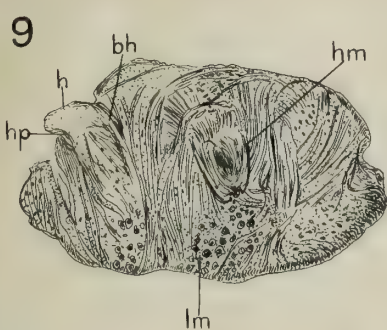
Fig. 10. Surface view of cuticle; x 250.

Fig. 11. Surface view of muscles of body wall; x250.

Fig. 12. Cross section of cuticle; x 400.

Fig. 13. Cross section of middle of head region; x 150.

Fig. 14. Cross section thru region of hind gut; x 50.



Explanation of Plate

Plate IV.

Abbreviations.

a	anal opening	hg	hook gland
ag	atrium genitale	hgd	hook gland duct
c	cuticle	hgt	hind gut
cb	cirrus bulb	hgw	wall of hook gland
ce	columnar epithelium	om	oblique muscle
co	coagulum	pe	parietal cells
cs	cirrus sac	sp	sperm bundle
ct	connective tissue	r	rugae
cw	wall of cyst	sg	stomach
ds	dilator rod sac	sh	sheath of hook
ej	ejaculatory duct	t	testis
ep	external protractor of hook	tm	transverse muscle
f	cross fibers of mesentery	tv	seminal tube
fl	flexor of hook	vd	vas deferens
ex	extensor of hook	vs	vesicula seminalis
		wm	wall of mesentery

Fig. 15. Ventro-lateral view of entire specimen showing the position of the hook glands; x 18.

Fig. 16. Ventral view of head showing muscular attachments of hooks; x 160.

Fig. 17. Male genital organs from the dorsal side; x 60.

Fig. 18. Lateral view of anterior male reproductive organs; x 55.

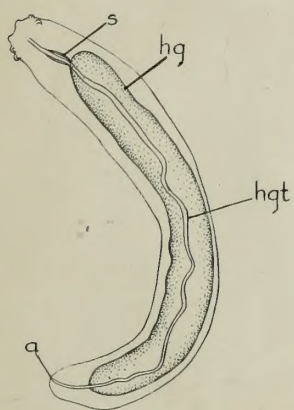
Fig. 19. Median section thru the hind gut; x 150.

Fig. 20. Ventral view of encysted larva; x 30.

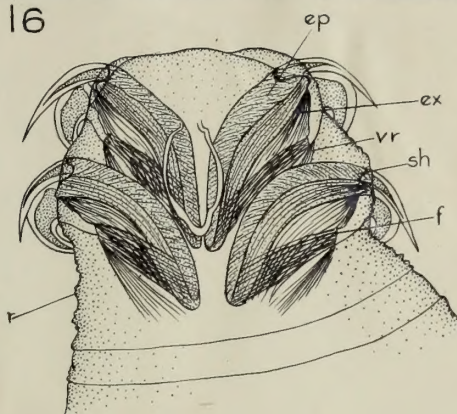
Fig. 21. Cross section showing the layers of the body wall; x 400.

Fig. 22. Cross section in region in region of hind gut showing connections of the mesentery; x 180.

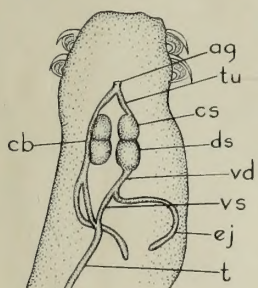
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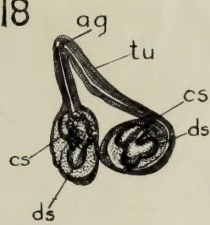
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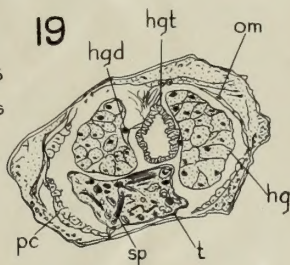
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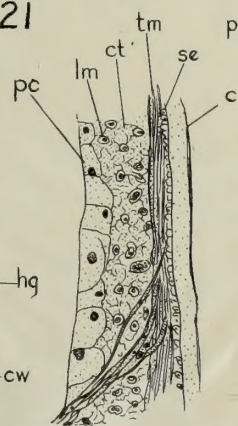
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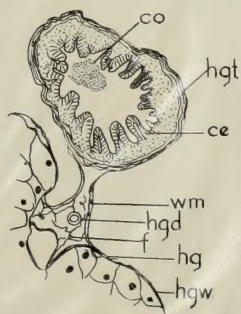
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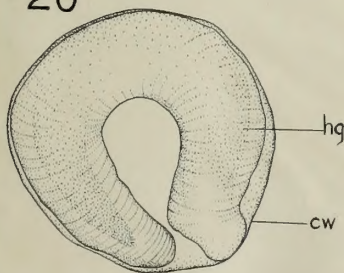
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